CALIOP Version 3 Data Products: A Comparison to Version 2

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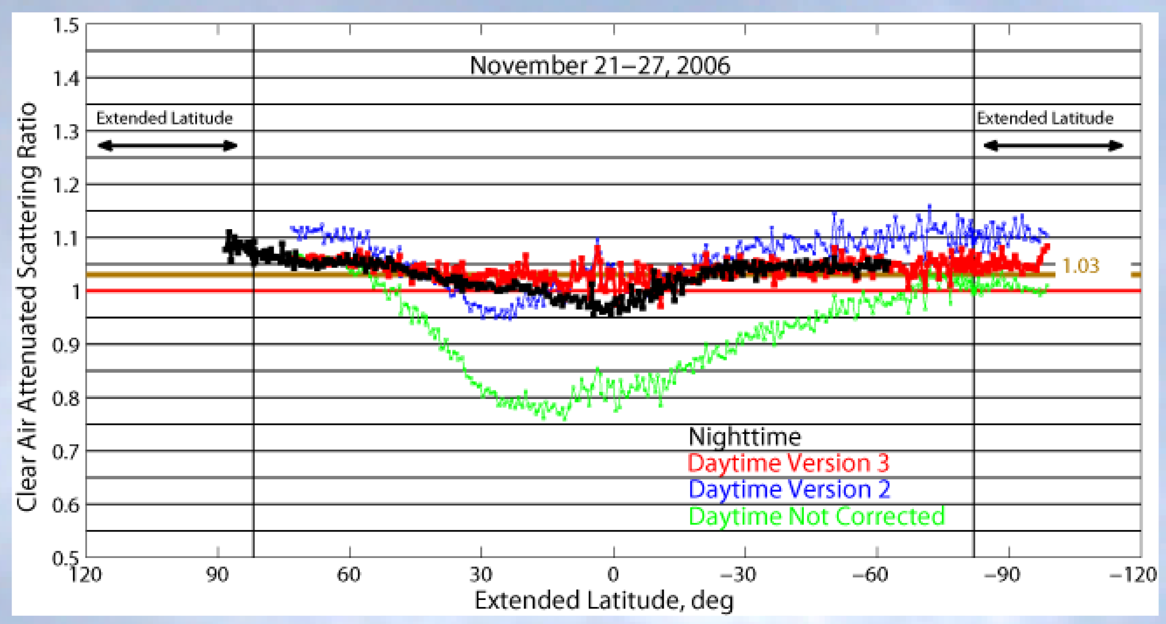
Daytime Calibration

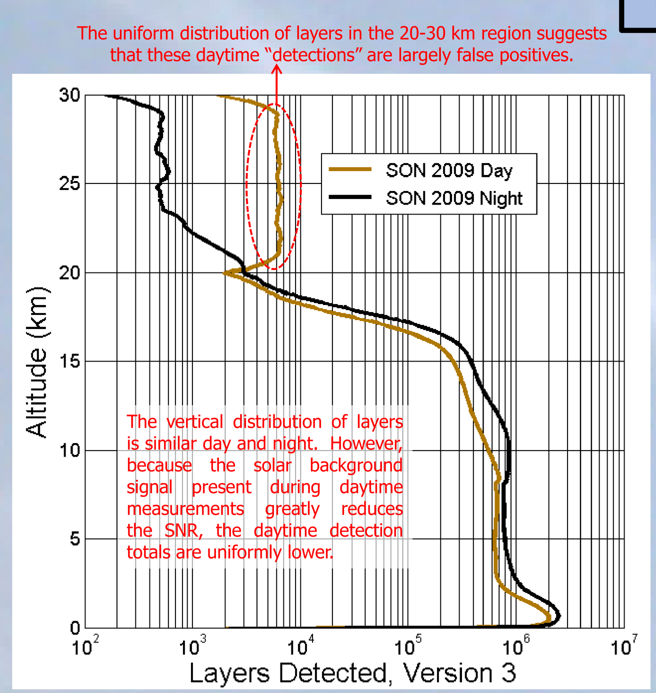
The Problem:
After launch we discovered that the CALIOP daytime measurements were subject to thermally induced beam drift, and this caused the calibration to vary by as much as 30% during the course of a single daytime orbit segment.

The Solution:
Using an algorithm developed by Powell et al. (2010), empirically derived correction factors are now computed in near real time as a function of orbit elapsed time, and these are used to compensate for the beam wandering effects



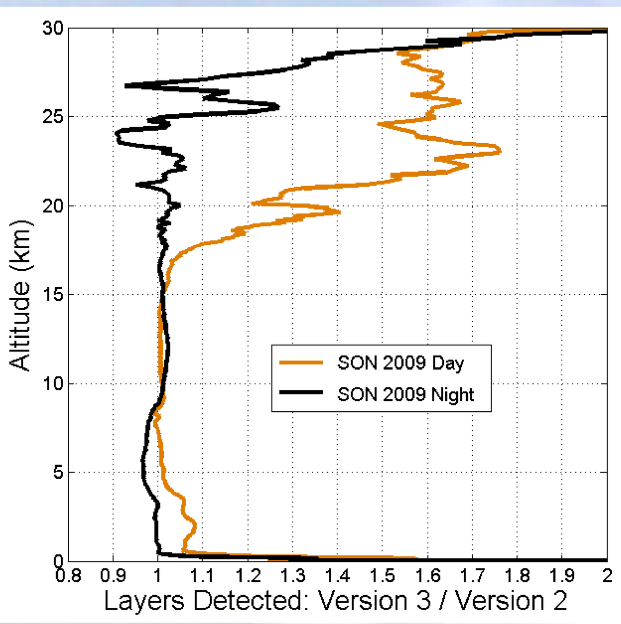
The black line shows the mean attenuated scattering ratio measured during nighttime in clear air regions between 8-km and 12-km. Assuming that the diurnal changes in aerosol loading in this region are insignificant, the weekly mean scattering ratio during daytime should be essentially identical to the weekly mean scattering ratio measured at night. As seen in the figure to the left, the correction coefficients computed for the version 3 processing perform substantially better than those used for version 2.

Layer Detection

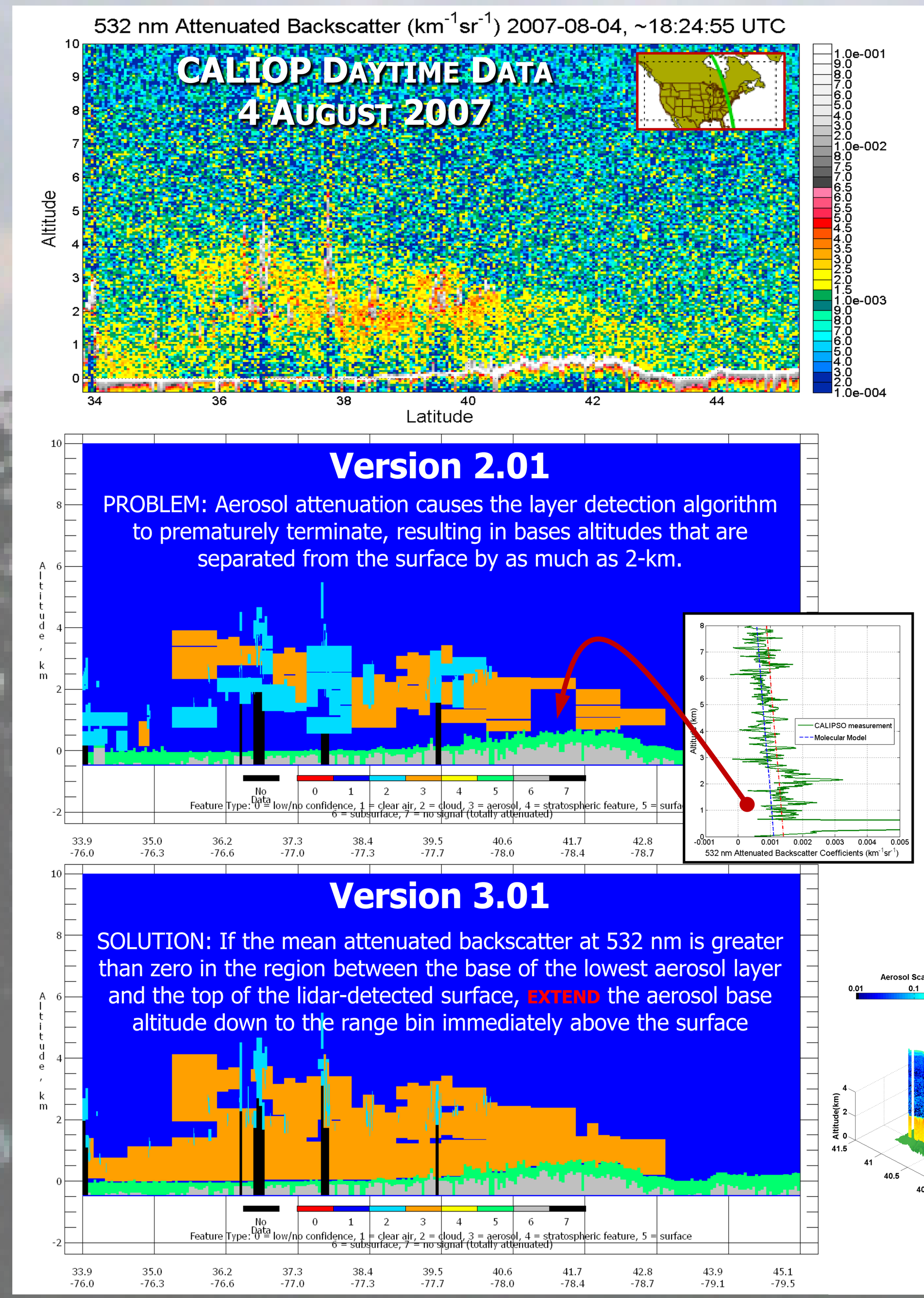


The figure to the left counts the number of range bins in which layers were detected in the CALIOP Version 3 data as a function of altitude for all data acquired during the fall months (September, October, November) of 2009. Layer detection counts are shown separately for daytime and nighttime data acquisition. The figure on the right shows the Version 3 daytime and nighttime layer detection frequencies as fractions of the Version 2 quantities. By examining these two figures, the following conclusions can be drawn:

1) Nighttime layer detection is largely unchanged from Version 2 to Version 3. Where large fractional changes are seen (right hand plot), the layer detection counts are especially low.
2) Daytime layer detection increases by a factor of ~50% above about 16-km, and by 5% to 8% below 4-km. Both changes arise from the same source: the changes made to the daytime calibration procedures, which increase the magnitude of the attenuated scattering ratio profiles that are used by the layer detection algorithms.



Aerosol Base Extension in the PBL

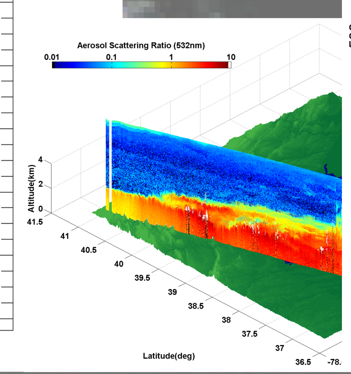


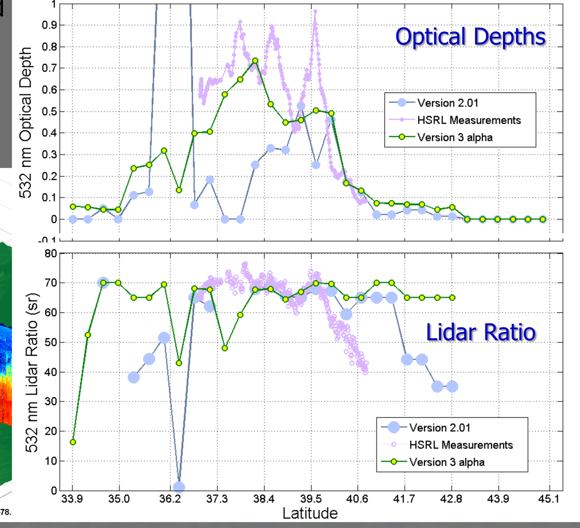
A new procedure has been incorporated into version 3 of the CALIPSO level 2 analyses. As was done in all previous versions, all features within a scene are assigned an initial classification by the cloud-aerosol discrimination (CAD) algorithm and either the aerosol sub-typing algorithm or the cloud phase algorithm. In the version 2 processing, the next and final step in the analysis was to launch the extinction and optical properties retrievals. For version 3 processing, an intermediate step is inserted: the initial classification is now followed by an assessment of the lowest layer within each column. If the lowest layer is initially classified as an aerosol and

a) the layer is not opaque (i.e., the surface was detected below);
b) the initial layer base is within some minimum distance of the surface (2.5-km for the version 3 processing); and
c) the 532 nm integrated attenuated backscatter in the region between the initial base altitude and the top of the surface echo is positive

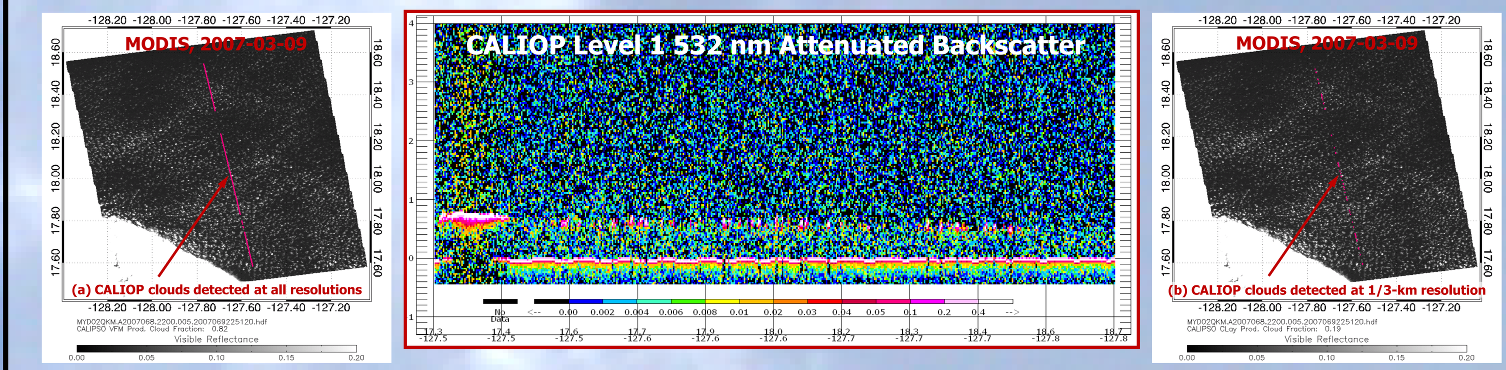
then the estimate of the layer base altitude is revised downward to a point three range bins (~90 m) above the top of the surface spike.

Comparisons to HSRL measurements made ~30 minutes earlier: Aerosol optical depth retrievals improve markedly when layer boundaries are extended



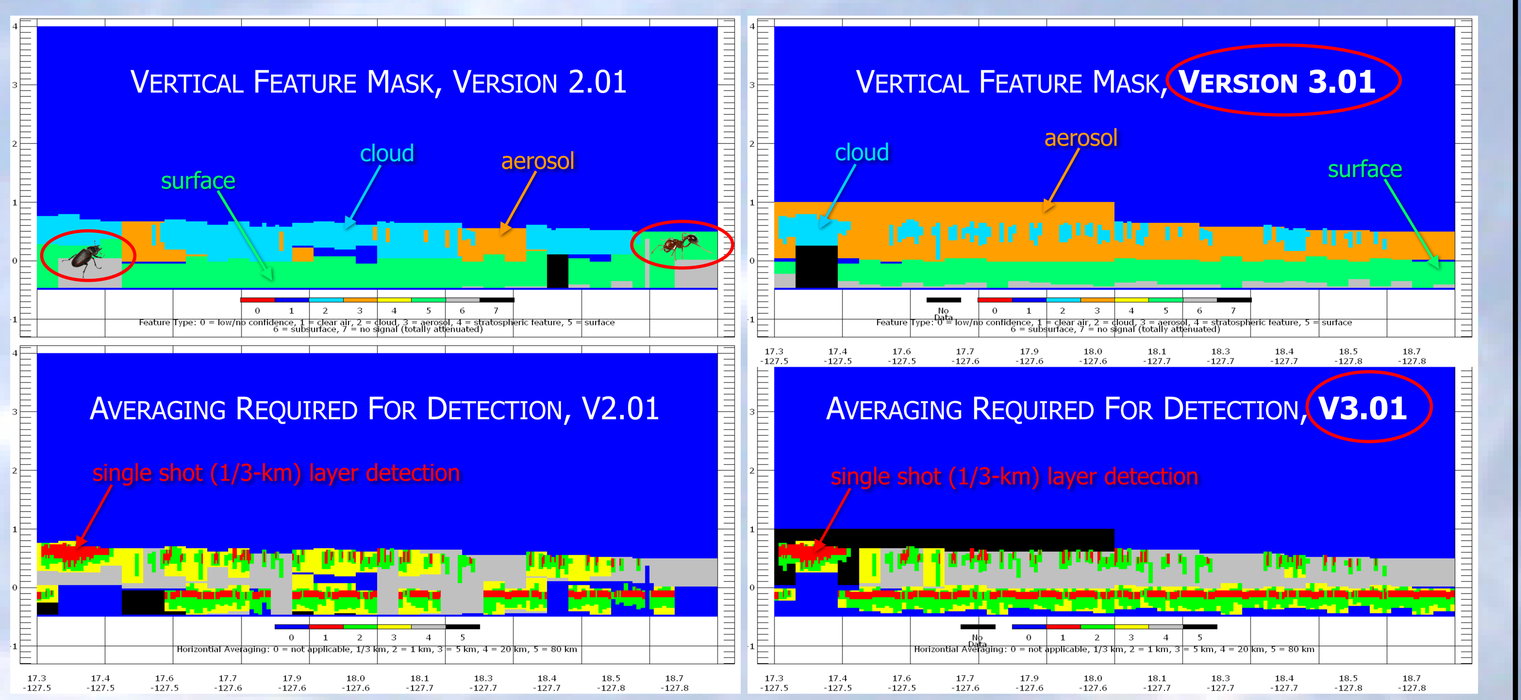


Cloud Clearing



The MODIS images above are overlaid with CALIOP cloud identifications (a) reported in the Version 2 vertical feature mask product (i.e., detected at all resolutions), and (b) reported in the Version 2 1/3-km layer product (i.e., detected at single shot resolution only). CALIOP's 1/3-km detection results are entirely consistent with the MODIS image. However, layers detected at coarser resolutions (1-km and above) are frequently misclassified as cloud. This situation is illustrated in the right two panels below, which show the layer classifications and layer detection resolutions reported in the CALIPSO version 2.01 data products. Compared with the CALIPSO Level 1 image (shown above between the MODIS images) the **layer detection** appears reasonably accurate; however, the **layer classification** is rife with errors. This state of affairs was subsequently determined to be strictly a coding error, and not related to algorithm design. The errors were traced to the cloud-clearing module, which, after removing high resolution clouds, failed to properly re-average all of the relevant quantities required by the cloud-aerosol discrimination routines. The results reported in the Version 3.01 data for this same scene are shown below in the two panels on the right.

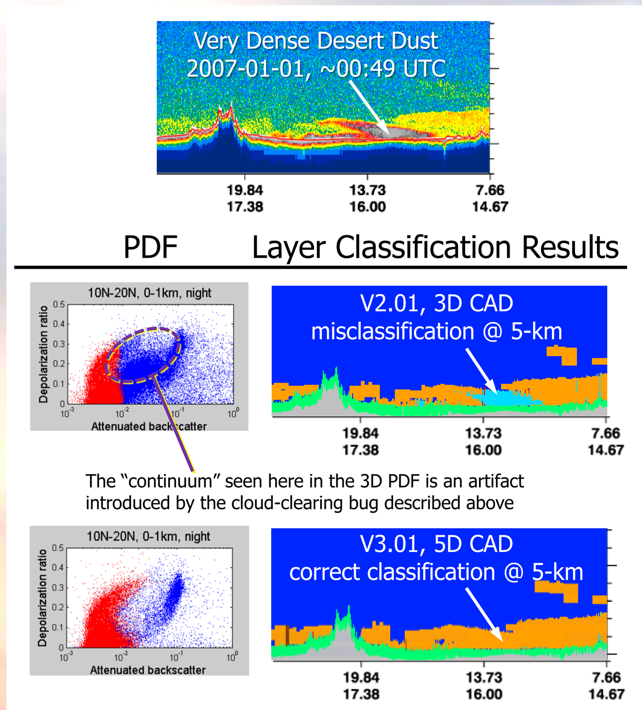
Many thanks to Chris Yost and members of the CERES team for the high quality bug report that led us to identify the source of this deep-seeded rascal.



Cloud-Aerosol Discrimination

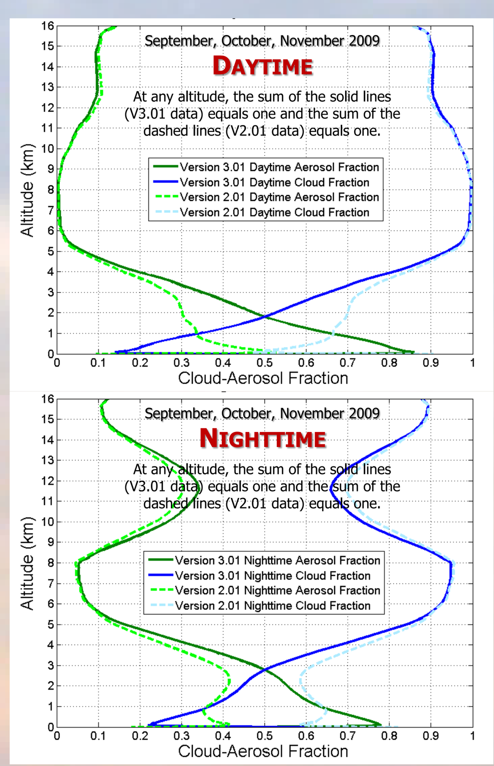
PDF Improvements

In version 2, the CALIOP cloud-aerosol discrimination (CAD) algorithm used three attributes to distinguish between feature types: the mean attenuated backscatter at 532 nm, the integrated attenuated back-scatter color ratio (1064/532), and mid-layer altitude. The version 3 CAD algorithm adds two addition attributes: latitude and layer integrated volume depolarization ratio. When these new 5 dimensional (5D) probability density functions (PDFs) are used, the resulting separation between clouds and aerosols is much more complete than when 3D PDFs are used. In particular, as demonstrated in the plots to the right, the 5D PDFs provide a much improved ability to distinguish very dense aerosol layers from clouds.



Other CAD Changes

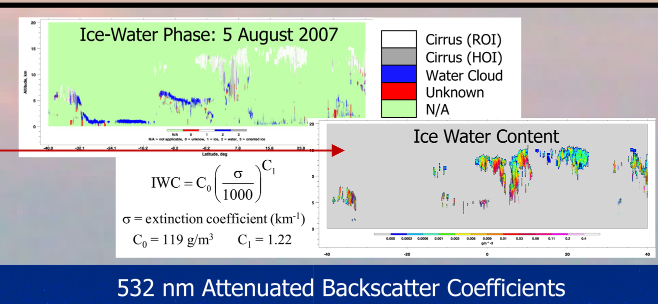
While the operation of the CAD algorithm changed somewhat (i.e., the original 3D PDFs were replaced with 5D PDFs), in the planetary boundary layer (PBL) a much larger change in the fraction of layers identified as aerosols occurred as a result of the repairs made to the cloud-clearing codes. This change is illustrated in the plots to the right, which show globally compiled vertical profiles of cloud and aerosol fraction for both daytime and nighttime and both version 2 and version 3. These profiles are derived using all data acquired during the fall of 2009.



New Profile Product Architecture

New Parameters

- Particulate Depolarization Ratios
- Cloud Ice-Water Content
- Column Optical Depths for Clouds and Aerosols
- Uncertainties for all Optical Properties



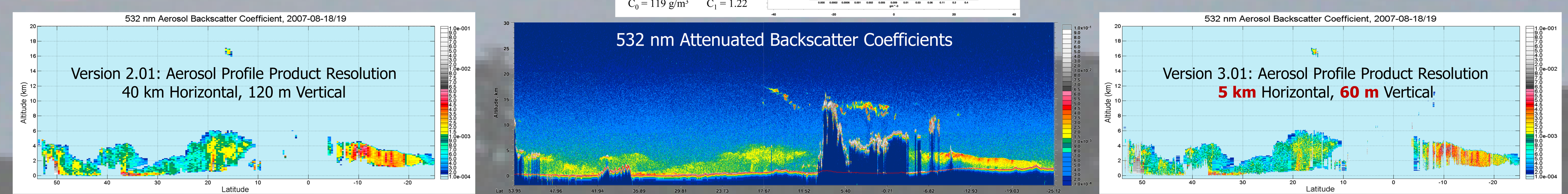
$$IWC = C_0\left(\frac{\sigma}{1000}\right)^{C_1}$$

σ = extinction coefficient (km^{-1})

$C_0 = 119\ g/m^3$ $\quad C_1 = 1.22$

Enhanced QA/QC Information

- Extinction QC Flags
- Classification Confidence (CAD Scores)
- "Atmospheric Volume Description"
- Initial Lidar Ratios



http://www-calipso.larc.nasa.gov/